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ABSTRACT

The relationship of attitudes toward mathematics to mathematics performance, gender, mathematics course-taking plans, and career interests were investigated. Students enrolled in public middle and high school mathematics courses (722 male, 794 female) served as subjects. The Fennema-Sherman Math Attitude scales were used to measure attitudes toward mathematics, a background/future plans questionnaire was administered to assess course-taking plans and career interest, and final mathematics course grade was used as a measure of mathematics performance. Results showed that attitudes toward mathematics were predictive of final mathematics course grade and the intention to continue to participate in mathematics courses once enrollment becomes optional. Attitudes also discriminated among students with different career interests. Students in more accelerated mathematics "tracks" had more positive attitudes, greater intention of taking optional mathematics classes, and were interested in more mathematically-related careers. Males and females were equally likely to express plans to take mathematics courses once participation became optional. Overall, females' attitudes were more positive than expected. However, their lack of confidence in their abilities to learn mathematics and their higher levels of mathematics anxiety, coupled with a lack of interest in more mathematically-related careers, suggest that important gender differences still exist. (Author)

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Attitudes Toward Mathematics: Relationships to Mathematics Achievement, Gender, Mathematics Course-taking Plans, and Career Interests

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Abstract

The relationship of attitudes toward mathematics to mathematics performance, gender, mathematics course-taking plans, and career interests were investigated. Students enrolled in public middle and high school mathematics courses (722 male, 794 female) served as subjects. The Fennema-Sherman Math Attitude scales were used to measure attitudes toward mathematics, a background/future plans quesionnaire was administered to assess course-taking plans and career interests, and final mathematics course grade was used as a measure of mathematics performance. Results showed that attitudes toward mathematics were predictive of final mathematics course grade and the intention to continue to participate in mathematics courses once enrollment becomes optional. Attitudes also discriminated among students with different career interests. Students in more accelerated mathematics "tracks" had more positive attitudes, greater intention of taking optional mathematics classes, and were interested in more mathematically-related careers. Males and females were equally likely to express plans to take mathematics courses once participation becomes optional. Overall, females' attitudes were more positive than expected. However, their lack of confidence in their abilities to learn mathematics and their higher levels of mathematics anxiety, coupled with a lack of interest in more mathematically-related careers, suggest that important gender differences still exist.

Introduction

The existence and possible causes of sex-related differences in mathematical achievement have been hotly debated in the educational and psychological literature for the past several decades. While it is generally accepted by the public and much of the academic community that males outperform females on mathematical tasks by mid-adolescence (Benbow & Stanley, 1980; Eccles & Jacobs, 1986; Fennema & Sherman, 1977; Hyde, Fennema, & Lamon, 1990; Linn & Hyde, 1989), researchers have disagreed on the reasons for these observed differences. In recent years, attitudinal and affective variables such as confidence in learning mathematics, mathematics anxiety, and mathematics self-efficacy have emerged as salient predictors of both achievement in mathematics and of mathematics avoidance which indirectly affects mathematical achievement (Eccles & Jacobs, 1986; Hackett & Betz, 1989; Kloosterman, 1988). Many researchers have maintained that social forces, such as messages pertaining to appropriate sex role behavior and attitudes of parents and teachers toward mathematics and toward the child as a learner of mathematics, as well as the individual's personal experiences with mathematics, shape his or her attitudes toward and expectations of success in mathematics.

Women's and girls' attitudes about mathematics have generally been found to be more negative than those of males (Linn & Hyde, 1989). It has been proposed that these sex-related differences in attitude are both directly and indirectly responsible for the observed sex-related differences in achievement in and avoidance of mathematics (Aiken, 1976; Bassarear, 1986; Eccles & Jacobs, 1986; Fennema, 1980; Hackett, 1985; Sells, 1980; Yee & Eccles, 1988). The practical implication of women's negative attitudes about, subsequent avoidance of, and lower levels of achievement in mathematics is the severe limitation of career options (Sells, 1980; Singer & Stake, 1986). Scientific and technological fields in particular require a great deal of mathematics. Lower levels of self-confidence and mathematics self-efficacy, coupled with a higher incidence of mathematics anxiety experienced by women decrease the likelihood of adequate mathematical preparation in high school. For this reason, mathematics has been called a "critical filter," serving to shut off many opportunities to women (Sells, 1980).

Psychological Theories Relating to the Development of Attitudes

Attribution Theory. According to attribution theory, people are motivated by two needs. The first of these is an individual's need to understand his or her environment and

the second is the desire for control over this environment. In order to meet these needs, individuals must be able to predict both the events around them and their behavior in response to these events (Houston, 1985).

In attempting to make these predictions, individuals base future expectations on past experience. When an individual experiences an outcome of a situation, he or she seeks to understand the cause of that outcome. In academic situations the outcomes in question are primarily whether the individual has achieved success on a given task or whether he or she experiences failure (Dweck & Licht, 1980).

Weiner (1979) has identified three dimensions of causality: locus of causality, control, and stability. Locus of causality refers to the degree to which an individual perceives reinforcements to be contingent on his or her own responses. It is an internal-external dimension. An internal attribution reflects the belief that outcomes are dependent on the individual's behavior. In this formulation, contingency and control are considered separately. Thus, some internal causes are thought to be under the control of the individual and others are not. The stability dimension refers to whether the perceived cause of an outcome is believed to be relatively stable or recurrent or whether it is thought to be unstable, short-lived, or intermittent (Weiner, 1974).

While Weiner claimed that these dimensions are orthogonal, it seems unlikely that this is the case. Most external causes would not be controllable by the individual. In addition, a logical relationship can be drawn between control and stability. Unstable causes such as effort are more controllable than stable causes such as ability (Stipek & Weisz, 1981).

In an achievement situation, individuals tend to attribute success or failure to one of four factors. These factors are ability, effort, task difficulty, and luck and are directly related to the dimensions of locus of causality, control, and stability in Weiner's attribution theory. Ability is considered an internal, uncontrollable, and stable factor. Effort is internal, controllable, and unstable. Luck and task difficulty are external factors because they are considered independent of the individual's responses. Luck is generally viewed as unstable but if an individual believed himself or herself to be a "lucky" person then an attribution to luck would be classified as a stable factor (Houston, 1985; Weiner, 1974; 1979).

Attributions for success and failure have a great deal to do with motivation in achievement situations and with subsequent performance. Weiner (1974) believed that high-achievers and low-achievers attribute success and failure to different causes. High-achieving people attribute past

success to the internal factors of ability and effort. They believe that since those factors have led to success in the past, they will continue to do so in the future. High-achievers, therefore, have an expectation of future success. These individuals also tend to attribute failure to lack of effort. They believe that future success can be attained if they try harder. Individuals with this attributional pattern are often referred to as mastery-oriented.

Low-achieving people, on the other hand, tend to attribute past failures to lack of ability and past successes to external sources. Since an internal, uncontrollable, stable factor is blamed for failure, these individuals develop the expectation of future failure. They perceive reinforcement to be independent of their actions so there is little motivation for them to expend much effort in the future. These individuals may develop the tendency to give up quickly or display reduced effectiveness of problem-solving strategies when faced with failure (Parsons, Meece, Adler, & Kaczala, 1982). This cluster of characteristics has been termed "learned helplessness" (Houston, 1985). Motivation is thus explained by attribution theory in terms of the perceived causes to which students attribute their successes and failures (Kloosterman, 1988). Uguroglu and Wahlberg (1986) found that level of motivation correlated highly with achievement measures.

Bandura's Social Learning/Self-Efficacy Theory.

Bandura's original social learning theory was concerned with the interactions among personal, behavioral, and environmental factors. These three factors were thought to exert reciprocal influences on one another. Throughout this process, individuals learn what behaviors bring about desired changes in the environment and what environmental situations necessitate certain behaviors. Individuals also discover that some outcomes are and some outcomes are not contingent on their actions (Bandura, 1977a; Norwich, 1987; Stipek & Weisz, 1981).

If it is determined that a certain outcome is contingent on a particular course of action, then an individual must evaluate whether or not he or she is capable of making the necessary response. The belief an individual holds regarding his or her ability to perform the behavior required to bring about a desired outcome has been termed "self-efficacy expectation." Self-efficacy expectation is a personal cognitive factor presumed to mediate between an individual's behavior and factors in his or her environment. Past performances, cues and messages from relevant others such as parents, teachers, and peers, and levels of emotional arousal all contribute to judgments about one's efficacy (Bandura, 1977b, 1982).

An individual's beliefs about his or her ability to successfully execute the behaviors required to bring about a certain outcome help to determine whether a person will even attempt the necessary course of action. If the behavior is attempted, efficacy expectations influence how long an individual will persist if he or she encounters difficulties (Norwich, 1987; Stipek & Weisz, 1981). Those who doubt their ability to bring about the desired consequence (i.e., with low self-efficacy expectations) are less likely to initially attempt the responses of which they are uncertain and are more likely to give up quickly in the face of frustration. Because of these motivational effects, self-efficacy is considered a relevant variable when looking at academic achievement.

Factors Proposed to Affect Achievement in Mathematics

Women and Mathematics. In 1973, a survey was conducted at the University of California at Berkeley to determine the extent of high school math preparation among the incoming freshman (Richardson & Woolfolk, 1980; Sells, 1980). Completion of four years of high school mathematics was a prerequisite for many of the institution's mathematics, science, and statistics courses. Of the incoming males, 57 percent had completed four years of high school mathematics whereas only 8 percent of the entering females had completed enough mathematics preparation to

participate in college level mathematics and science courses. Because of this discrepancy in the amount of mathematics taken in high school by males and females, mathematics has been termed the "critical filter," effectively eliminating women from many college majors and career opportunities (Richardson & Woolfolk, 1980; Sells, 1980).

A number of researchers have sought explanations for the observed gender differences in mathematics acheivement and participation in high school mathematics. In 1980, a highly controversial article by Benbow and Stanley was published in Science. In that article, commonly found sex differences on the Scholastic Aptitude Test for Mathematics (SAT-M) were attributed to innate "superior male mathematical ability." This interpretation was challenged by a number of other researchers. Some maintained that sex differences in mathematics achievement, which do not appear until grade eight or nine, are caused primarily by differences in the number of mathematics courses taken rather than a female inability to learn mathematics (Eccles & Jacobs, 1986; Richardson & Woolfolk, 1980; Sherman, 1982). As stated above, males typically take more mathematics courses in high school than females (Ernest, 1980; Fennema, 1980). Sherman (1982) noted that little difference is found in males' and females' mathematical performance in studies

that control for background in mathematics. Since Benbow and Stanley did not consider the amount of formal exposure to mathematics (i.e., the number of math courses taken) in their analyses, it seems appropriate that their interpretation of their results be viewed with skepticism.

Other researchers have asserted that certain informal activities, such as playing with blocks and building models, are also more commonly experienced by boys and that these experiences may help develop spatial visualization skills which may contribute to males' superior performance on mathematical tasks (Fennema & Sherman, 1977). Male superiority on tests of spatial ability emerges at about the same time as differences in mathematical achievement, in early adolescence.

A cross-cultural comparison of sex-related differences in mathematical achievement and mathematics attitudes in twenty countries revealed that in some countries males outperform females on mathematical tasks, whereas, in other countries females outperform males (Hanna & Kuendiger, 1986). Differences in achievement were related to differences in attitudes toward mathematics and to societal differences in the level of gender stereotyping. Girls equaled or outperformed boys in the countries where it was believed that the study of mathematics was appropriate and important for girls, the attitudes of girls toward

mathematics were positive, and girls received support and encouragement at home to study mathematics. The role of parents and teachers in the development of childrens' attitudes toward mathematics and the subsequent effect of these attitudes on mathematical performance will be discussed in some detail later.

In the United States, Richardson and Woolfolk (1980) have found that males and females tend to respond to academic successes and failures with different patterns of causal attributions. When high school boys and girls with the same level of intellectual ability were asked why they had done poorly on a mathematical task, females tended to attribute their failure to a lack of ability significantly more often than males, whereas males generally attributed their failure to a lack of effort. As discussed earlier, attributions of failure to internal, uncontrollable, stable factors such as ability often result in the expectation of future failure, a depressed level of motivation, and learned helplessness. Dweck and Licht (1980) found girls were more likely than boys to exhibit learned helplessness in achievement situations.

The Influence of Parents and Teachers. Dweck and Licht (1980) proposed that the sex-related differences in patterns of attributions they observed were due, at least in part, to the feedback a child receives from his or her teachers about

the reasons for academic successes and failures. In addition, it seems that beginnings of these attitudes can be found quite early in a child's school experience. In their studies of elementary school children, Dweck and Licht found that boys typically received more negative feedback from teachers than girls. Boys were more disruptive in class, more aggressive on the playground, etc. and were, therefore, reprimanded more often. Based on these findings, they hypothesized that if a boy receives negative feedback because he has performed poorly academically, he can easily attribute the cause of his failure to various nonintellectual referents such as teacher bias or lack of effort. Consequently, negative feedback loses its meaning as a clear assessment of academic performance and ability for boys. However, one would expect that negative feedback would be more likely to be seen by girls as suggesting lack of ability if the teacher is generally quite positive toward them. This would be especially true if the teacher failed to provide alternative explanations, such as lack of effort, for girls' intellectual failures.

It has been proposed that parents also play an important role in forming their children's perceptions of the causes behind academic successes and failures. Yee and Eccles (1988) found that while parents tended to attribute both their sons' and daughters' failures in mathematics to

lack of effort, parental attributions for math successes differed for boys and girls. Ability was more often credited for the successes of sons than for daughters and daughters' successes were attributed to effort more often than sons'. These effects were more pronounced for attributions made by mothers. Since ability is a stable attribution and effort is unstable, parents may be conveying doubts about the probability of future math success for their daughters while communicating confidence in their sons.

Parents may also unwittingly communicate their own attitudes toward mathematics to their children. Fabricant (1985) stated that parents who express negative attitudes about mathematics may, in fact, be teaching those negative attitudes to their children. However, other researchers (Parsons, Adler, & Kaczala, 1982; Sherman, 1982) have failed to find much support for this "modeling hypothesis." A parent's personal attitude toward mathematics seems to be much less important than the level of confidence he or she communicates in the child's ability to succeed in mathematics (Parsons et al., 1982).

Confidence in Learning Mathematics. Confidence in one's ability to learn mathematics has been stressed by many researchers as one of the more important variables for predicting both achievement in mathematics and mathematics

course enrollment (Kloosterman, 1988; Schoenfeld, 1989; Sherman, 1983). Students with high levels of self-confidence have been shown to display attributional styles that are mastery-oriented. They tended to attribute success to ability or high effort and failure to a lack of effort. These individuals were highly motivated due to their belief that future success was controllable and was contingent on their behavior. Kloosterman (1988) found that pattern of casual attributions accounted for 17% of the variance in self-confidence scores, indicating that a student's confidence in his or her ability to learn mathematics can be explained in part by perceptions of the causes behind his or her academic successes and failures. Females tended to express significantly less confidence in their mathematical abilities than males did even when their actual ability levels were objectively the same (Sherman, 1983) and girls' levels of confidence tended to drop even lower after a failure experience (Singer & Stake, 1986). Students who are confident in their abilities to learn mathematics are more likely to enroll in mathematics courses when enrollment becomes optional (Kloosterman, 1988). Lower levels of mathematics self-confidence observed among women and girls may, therefore, be one explanation for the lack of female participation in higher levels of mathematics (Fennema, 1980).

Mathematics Self-Efficacy. The variable of mathematics self-efficacy is similar to, yet distinct from, self-confidence in learning mathematics (Hackett, 1985). Confidence is a fairly global estimate of how one expects to do in mathematics courses in general. Self-efficacy refers to a more specific expectation about one's ability to successfully perform the task at hand.

Interestingly, Hackett and Betz (1989) found that a majority of both males and females inaccurately assessed their capabilities when asked how well they would perform on a set of mathematical problems. This relatively weak judgment/performance correspondence in mathematics is substantially lower than levels of judgment/performance correspondence in most other areas of achievement. However, researchers have found that social learning variables such as self-efficacy accounted for a significant amount of the variance in mathematics performance (Siegal, Galassi, & Ware, 1985). In the view of self-efficacy theory, efficacy expectations are formulated based not only on past performances, but also on social cues and emotional arousal (Bandura, 1977b, 1982). Singer and Stake (1986) found that students with low mathematics performance expectancies also tended to attribute failures to lack of ability, an internal, stable attribution.

In a path analysis, Hackett (1985) found sex role socialization and amount of mathematics preparation to be predictive of level of mathematics achievement, which was in turn predictive of mathematics self-efficacy. Mathematics self-efficacy was found to be predictive of both mathematics anxiety, mathematics course taking plans, and selection of a mathematics-related college major. Indeed, mathematics self-efficacy was found to be a more important predictor of mathematics-related major than either mathematics achievement or mathematics performance (Hackett & Betz, 1989).

Mathematics Anxiety. The problem of mathematics anxiety, defined as feelings of tension, helplessness, and mental disorganization when required to manipulate numbers (Hunsley, 1987), is thought to be quite prevalent in our society (Betz, 1978). It appears to be closely related both to confidence in one's ability to learn mathematics and to self-efficacy (Hackett & Betz, 1989; Kloosterman, 1988). While some researchers view mathematics anxiety as nothing more than subject-specific test anxiety (Kagan, 1987), others believe that mathematics anxiety is a distinct construct (Dew, Galassi, & Galassi, 1983; Hembree, 1990). Moderate correlations among mathematics anxiety scales provide some evidence for construct validity. Additionally, measures of mathematics anxiety correlate more highly with

each other than they do with measures of test anxiety (Dew et al., 1983). Therefore, although the two constructs do seem to be related, they are not interchangeable.

Some researchers have claimed that mathematics anxiety is gender-related. Wigfield and Meece (1988) reported that among elementary and secondary school-aged children, girls had stronger and more frequent negative affective reactions to mathematics than boys. Mathematics anxiety was also found to be more prevalent among college women than among college men (Betz, 1978). However, others have maintained that it is the amount of experience with mathematics, not gender, that is predictive of mathematics anxiety in college students (Llabre & Suarez, 1985; Richardson & Woolfolk, 1980). As discussed earlier, females typically take fewer mathematics courses in high school than males.

There is conflicting evidence regarding the ability of measures of mathematics anxiety to predict achievement in mathematics. Hendel (1980) found that knowledge of a student's level of mathematics anxiety contributed substantially to the prediction of mathematics performance. Conversely, Resnick, Viehe, and Segal (1982) found that knowledge of a subject's level of mathematics anxiety led to no improvement in prediction of subjects' performance scores. However, the sample in the latter study consisted entirely of college students with extensive backgrounds in

mathematics. It is likely that the range of severity of mathematics anxiety was severely limited in the Resnick et al. sample.

Hembree (1990) found that levels of mathematics anxiety increased through junior high school, peaked at grades 9-10, and then leveled off for the last years of high school and college. For grades five through twelve, higher levels of mathematics anxiety related to lower mathematics performance. Hembree suggested that mathematics anxiety may depress performance on mathematical tasks since reduction in anxiety consistently lead to higher levels of achievement. Highly anxious students also took fewer mathematics courses in high school and rarely expressed plans to pursue a mathematics- or science-related major in college.

Problem Statement

The purpose of the present study was to examine the relationships of the various attitudinal and affective variables discussed above to gender, mathematics achievement, and students' mathematics course taking and career plans. It was expected that attitudes toward mathematics would be positively related to mathematics performance, intention to take higher level mathematics courses, and expressed interest in a mathematics-related career. It was further hypothesized that attitude scores would be predictive of mathematics performance, mathematics

course-taking plans, and career interest. Males were expected to have more positive attitudes toward mathematics, to show greater intention of taking higher level mathematics courses, and to express more interest in mathematics-related careers than females. Additionally, the role of mathematics "tracks" was investigated with the expectation that students in more advanced, accelerated "tracks" would display more positive mathematics attitudes, be planning to take higher level mathematics courses, and express more interest in mathematics-related careers than students in regular or remedial "tracks."

Method

Subjects

The subjects in this study were 1516 (722 male, 794 female) students enrolled in public middle and high school mathematics courses. An additional 226 students took the survey but their responses where not considered for analysis because they either elected not to finish the survey or did not follow directions for completing it (such as answering items true or false instead of using the 5-point scale provided). Of the 1516 students whose responses were analyzed, 952 were attending one of three middle schools and 564 were attending one high school. Of the 952 middle school students, 4 (1 male, 3 female) were in 6th grade; 441 (219 male, 222 female) were in 7th grade; and 507 (239 male,

268 female) were in 8th grade. Of the 564 high school students, 254 (125 male, 129 female) were in 9th grade; 221 (97 male, 124 female) were in 10th grade; and 89 (41 male, 48 female) were in 11th or 12th grade. The courses in which these students were enrolled ranged from regular "track" 7th grade mathematics to high school geometry (the most advanced course in which accelerated "track" 10th grade students were enrolled during the semester the survey was administered). In addition, 15 middle school students were enrolled in a special mathematics course developed for those who tested in the top 2-3 percent of their class in 5th grade. This course will be referred to as "special mathematics" throughout the remainder of this paper and specific characteristics of it will be discussed in detail later.

Instruments

Fennema-Sherman Mathematics Attitude Scales. All nine of the Mathematics Attitude Scales (Fennema & Sherman, 1986)--Confidence in Learning Mathematics, Father, Mother, and Teacher Scales measuring perceptions of attitudes toward one as a learner of mathematics, Effectance Motivation in Mathematics, Attitude toward Success in Mathematics, Mathematics as a Male Domain, Usefulness of Mathematics, and Mathematics Anxiety--were administered. Appendix A includes a description of each of these scales. Each scale contained 12 items that were scored on a 5-point Likert scale from 1

(strongly agree) to 5 (strongly disagree). Half of the items on each scale were worded negatively and half were worded positively; those that were worded positively were reverse-scored, and item scores were added to obtain the scale score. A high score on the Mathematics Anxiety Scale was indicative of a low level of math anxiety. On all other scales, a high score was indicative of a positive attitude. These scales have been shown to be highly reliable, with KR20 values ranging from .86 to .90 (Hackett & Betz, 1989).

Background and Future Plans Questionnaire. A series of questions was added to the math attitudes scales in order to gather demographic information as well as information relative to students' expectations of success in the course they were currently enrolled in, plans regarding future enrollment in mathematics courses, and career plans including anticipated college major if they planned to attend college. To gain a measure of math self-efficacy, students were asked to rate on a 5-point scale from 1 (no confidence) to 5 (complete confidence) how confident they were that they would obtain a B or better in their current math class. Students were told that there is a point in high school when participation in mathematics courses becomes optional. They were asked to rate on a 5-point scale from 1 (definitely will not continue to take mathematics) to 5 (definitely will continue to take

mathematics) the likelihood that they would continue to enroll in mathematics courses once participation became optional. The anticipated college majors/careers were rated according to Goldman and Hewitt's (1976) Science/math continuum, from the fine arts (1) to the physical sciences and mathematics (5).

The survey, as presented to the subjects, consisted of a cover sheet explaining how to answer the items and information about confidentiality, the demographic/plans questionnaire, and the Fennema-Sherman Math Attitude Scales. The items from all nine scales were combined so that every 9th item was from a given scale. Positively- and negatively-worded items were alternated throughout the survey (see Appendix B).

Materials

In addition to the survey, subjects were provided "Scantron" computer-scoreable answer sheets on which to mark their answers and #2 pencils.

Procedure

The survey was administered to all subjects during their usual mathematics class time. In the middle schools, surveys were administered in the individual classrooms where the subjects' mathematics classes were normally held. The majority of the high school students were surveyed in large groups in an auditorium because of the school

administration's constraint that the surveying be completed in one day. Due to the unavailability of the auditorium during one class period, students whose mathematics courses met during that hour were surveyed in their individual classrooms.

Instructions for completing the survey were read aloud to all students. The procedure for using the Likert scoring was described and directions for filling out the computer scored answer sheets were given. Students were asked to fill in their name, their teacher's name, and the title of the mathematics course they were enrolled in on their answer sheet. Students were told that their names were required only as a means to match their survey responses with their final grades. They were reassured that their answers would be kept confidential and neither their teacher nor their parents would have access to their personal answers.

An identification number was assigned to each subject and class lists (with both students' names and identification numbers) were given to instructors whose students had participated in the survey. The teachers were asked to enter each student's final mathematics grade in the space provided on the appropriate class list and to remove the portion of the sheet which contained students' names to assure confidentiality. Class lists containing final course

grades and ID numbers were submitted by teachers at the end of the quarter (middle schools) or semester (high school).

Results

Means and standard deviations for the nine Fennema-Sherman Math Attitude Scales, self-efficacy score, final mathematics course grade, and mathematics course-taking plans (likelihood of continuing to take mathematics courses once participation becomes optional) score appear in Table 1. Intercorrelations among the attitudinal variables are presented in Table 2.

Relationship between Attitudinal Variables and Performance

In order to explore the relationship of attitudes to performance, the attitude scale scores and the self-efficacy score (confidence in getting a "B" or better out of the current math course) were correlated with performance as measured by end of the quarter/semester grade. Correlations of the independent variables with performance are presented in Table 3.

While all of the attitude variables were significantly positively correlated with final mathematics course grade, the variable most highly related to performance was mathematics self-efficacy (r = .60); those who were more confident in their ability to earn a grade of "B" or better out of their current mathematics course received higher final grades. The next strongest correlation occurred

Table 1

Means and Standard Deviations for Attitudinal Variables, Final Mathematics Grade, and Mathematics Course-taking Plans

Variables	M	SD
Attitudinal Variables		
Confidence in Learning Mathematics	43.60	10.66
Mother Scale	45.92	8.79
Father Scale	44.40	8.25
Attitude toward Success in Mathematics	45.16	7.33
Teacher Scale	40.84	8.22
Mathematics as a Male Domain	50.09	9.75
Usefulness of Mathematics	46.33	10.07
Mathematics Anxiety	40.88	10.52
Effectance Motivation in Mathematics	38.32	9.60
Mathematics Self-efficacy	3.76	1.27
Final Mathematics Course Grade	2.55	1.15
Mathematics Course-taking Plans	3.58	1.29

Note: Measures based on N = 1516.

Table 2

Intercorrelations of Attitudinal Variables

	(C)	(M)	(F)	(S)	(T)
Confidence (C)	1.00				
Mother (M)	.55*	1.00			
Father (F)	.45*	.67*	1.00		
Success (S)	.37*	.49*	.45*	1.00	
Teacher (T)	.51*	.52*	.47*	.40*	1.00
Male Domain (MD)	.40*	.48*	.45*	.52*	.37*
Usefulness (U)	.58*	.64*	.53*	.51*	.46*
Anxiety (A)	.85*	.43*	.33*	.28*	.46*
Math Fun (MF)	.64*	.40*	.33*	.32*	.47*
Self-efficacy (SE)	.53*	.23*	.21*	.14*	.29*

	(MD)	(U)	(A)	(MF)	(SE)
Male Domain(MD)	1.00				
Usefulness (U)	.46*	1.00			
Anxiety (A)	.25*	.49*	1.00		
Math Fun (MF)	.19*	.54*	.64*	1.00	
Self-efficacy (SE)	.16*	.28*	.50*	.36*	1.00

*$p < .0001$
Note: A high score on the mathematics anxiety scale is indicative of a low level of anxiety

Table 3

Correlations of Attitudinal Variables and Mathematics Performance

	Final Math Course Grade
Confidence in Learning Mathematics	.53*
Mother Scale	.26*
Father Scale	.24*
Attitude Toward Success in Mathematics	.20*
Teacher Scale	.30*
Mathematics as a Male Domain	.21*
Perceived Usefulness of Mathematics	.29*
Mathematics Anxiety	.47*
Effectance Motivation in Mathematics	.33*
Mathematics Self-efficacy	.60*

*$p < .0001$

between confidence in learning mathematics and performance (r = .53); those who expressed more confidence in their ability to learn mathematics received higher final grades. Mathematics Anxiety also showed a moderately strong relationship to final grade (r = .47); those with lower levels of mathematics anxiety outperformed their more anxious counterparts.

A forward stepwise multiple regression analysis was conducted using end of the quarter/semester mathematics course grade as the dependent variable. The results are presented in Table 4. Of the independent variables used in the analysis (the nine Fennema-Sherman Math Attitude scale scores, the mathematics self-efficacy score, and gender), only three contributed significantly to the prediction of final mathematics course grade. The relationship of the composite of mathematics self-efficacy score, confidence in learning mathematics, and gender with final mathematics course grade was R = .66, R^2 = .43. These three variables accounted for 43 percent of the variance in mathematics performance as measured by end of the quarter/semester mathematics course grade.

Relationships between Attitudinal Variables and Mathematics Course-taking Plans

In order to evaluate the relationship of attitudes to mathematics course-taking plans (as measured by the

Table 4

Results of Stepwise Multiple Regression Analysis for the Prediction of Final Mathematics Course Grade

Significant predictors	Beta	*F*	*R*	R^2
		365.66*	.66	.43
Mathematics Self-efficacy	.43			
Confidence in Learning Mathematics	.31			
Gender	.12			

*$p < .00001$

likelihood of continuing to participate in mathematics courses once enrollment becomes optional), attitude scale scores and the mathematics self-efficacy score were correlated with the mathematics course-taking plans score. The correlations of the independent variables with mathematics course-taking plans appear in Table 5.

Although all attitude variables were significantly positively correlated to course-taking plans, some of the strongest relationships were observed between mathematics course-taking plans and the following variables: perceived usefulness of mathematics (r = .41), those who felt that mathematics would be useful to them in their future lives expressed a greater likelihood of enrolling in mathematics courses once such enrollment became optional; confidence in learning mathematics (r = .39), those with more confidence in their ability to learn mathematics were more likely to continue to take mathematics once it was no longer required; and effectance motivation in mathematics (r = .37), the more fun an individual thought mathematics was, the more likely he or she was to express plans to continue to take mathematics courses once they became optional.

A forward multiple regression analysis was conducted using the likelihood of continuing to enroll in mathematics courses once such enrollment becomes optional score as the dependent variable. Results of the analysis are presented

Table 5

Correlations Between Attitudinal Variables and Mathematics Course-taking Plans

	Mathematics Course-taking Plans
Confidence in Learning Mathematics	.39*
Mother Scale	.31*
Father Scale	.29*
Attitude toward Success in Mathematics	.23*
Teacher Scale	.29*
Mathematics as a Male Domain	.12*
Perceived Usefulness of Mathematics	.41*
Mathematics Anxiety	.34*
Effectance Motivation in Mathematics	.36*
Mathematics Self-efficacy	.36*

*$p < .0001$

Table 6

Results of Stepwise Multiple Regression Analysis for the Prediction of Mathematics Course-taking Plans

Significant predictors	Beta	F	R	R^2
		106.31*	.58	.33
Perceived Usefulness of Mathematics	.29			
Mathematics "Track"	.28			
Mathematics Self-efficacy	.21			
Mathematics as a Male Domain	-.15			
Effectance Motivation in Mathematics	.10			
Father Scale	.06			
Gender	.05			

*$p < .00001$

in Table 6. Of the independent variables used in the analysis (the nine Fennema-Sherman Math Attitude scale scores, the mathematics self-efficacy score, mathematics "track" level, and gender), seven significantly contributed to the prediction of whether a student would continue to take mathematics courses once they became optional. The combined relationship of these variables with the likelihood of continuing to take math once enrollment becomes optional was $R = .58$, $R^2 = .33$. The composite of these seven variables accounted for 33 percent of the variance in the dependent variable.

Relationships between Attitudinal Variables and Career Interests

The mean attitude score on each of the nine Fennema-Sherman Math Attitude scales for each of the five career interest categories (ranging from fine arts to physical sciences and mathematics) are provided in Table 7. A series of analyses of variance (ANOVAs) was conducted to explore the relationships between attitudes toward mathematics and career interests. The results of these ANOVAs are presented in Table 8. Tukey HSD tests were performed when post hoc analyses were warranted.

Students' attitudes toward mathematics were found to vary according to career interest on seven of the nine Fennema-Sherman Math Attitude scales. Students interested

Table 7

Means for Attitudinal Variables as a Function of the Five Career Interest Categories

	Fine Arts	Humanities	Social Sciences	Biological Sciences	Physical Sciences & Math
Confidence	39.83	41.90	43.34	44.38	48.07
Mother	44.12	45.26	45.95	46.24	48.16
Father	42.44	43.81	45.24	44.85	45.72
Success	44.46	45.10	45.46	45.17	45.75
Teacher	39.08	39.54	41.13	40.88	43.17
Male domain	50.16	51.44	49.69	50.40	49.78
Useful	42.96	45.18	45.59	47.85	50.60
Anxiety	36.99	38.86	40.34	42.14	45.11
Math Fun	34.98	35.89	37.52	39.98	42.03

Table 8

Results of Analyses of Variance (ANOVAs) for Attitudinal Variables as a Function of Career Interests

Variables	MS_e	F (df = 4,1456)	p
Confidence in Learning Mathematics	105.34	27.42	.00001
Mother Scale	75.04	9.05	.00001
Father Scale	66.51	8.33	.00001
Attitudes Toward Success in Mathematics	53.37	1.43	.22
Teacher Scale	65.77	11.24	.00001
Mathematics as a Male Domain	94.63	0.87	.48
Perceived Usefulness of Mathematics	93.85	28.23	.00001
Mathematics Anxiety	103.96	28.19	.00001
Effectance Motivation in Mathematics	86.38	28.43	.00001

in careers in physical sciences and mathematics expressed more confidence in their ability to learn mathematics, perceived their mother's and teacher's attitudes toward them as learners of mathematics as more positive, felt mathematics would be more useful to them in their future lives, reported experiencing less mathematics anxiety, and got more enjoyment from performing mathematical tasks than did students interested in any other career category. While no differences were found between the perceptions students interested in physical sciences and mathematics, biological sciences, and social sciences had of their fathers' attitudes toward them as learners of mathematics, students interested in these categories perceived their fathers' attitudes to be more positive than students interested in fine arts did.

Students interested in biological sciences felt mathematics would be more useful to them in the future than did students interested in either social sciences or fine arts. They also reported less mathematics anxiety than students interested in humanities or fine arts and found mathematics more enjoyable than students interested in social sciences, humanities, or fine arts did. Those interested in biological sciences and those interested in social sciences expressed equivalent levels of confidence in their ability to learn mathematics, and perceived their

mothers' and teachers' attitudes toward them as learners of math to be equally positive. However, these students were more confident and felt their mothers' and teachers' attitudes were more positive than students interested in fine arts did.

Students interested in social sciences saw mathematics as more useful in their future lives, expressed lower levels of mathematics anxiety, and found mathematics to be more fun than students interested in fine arts did.

No differences in attitude toward success in mathematics or toward mathematics as a male domain were found among the career interest categories. Regardless of career interest, students showed equally positive attitudes toward success in mathematics and held equivalent views regarding stereotypes of male superiority in mathematics and the appropriateness of mathematics as an area of study for females.

A discriminant function analysis was performed in order to find a composite of the nine Fennema-Sherman attitude variables that would best discriminate among the five career interest categories. Results of the analysis are presented in Table 9.

The first function had a significant chi-square ($\chi^2(36) = 244.60$, $p = .00001$), indicating that the group centroids of the five career interest groups were not equal.

Table 9

Results of Discriminant Function Analysis of Attitudinal Variables and the five Career Interest Categories

Significant Functions	Canonical Correlation	Chi-square	df	p
Function 1	.36	244.60	36	.00001
Function 2	.13	39.92	12	.02

Standardized Canonical Discriminant Function Coefficients

	Function 1	Function 2
Confidence in Learning Mathematics	0.19	0.53
Mother Scale	-0.08	-0.11
Father Scale	0.06	0.72
Attitude Toward Success in Mathematics	-0.20	0.41
Teacher Scale	0.10	0.44
Mathematics as a Male Domain	-0.49	-0.70
Perceived Usefulness of Mathematics	0.70	-0.49
Mathematics Anxiety	0.27	-0.21
Effectance Motivation in Mathematics	0.21	-0.50

The relationship between group membership and the first composite of the attitude variables was $R = .36$. The composite of variables that made up the first function primarily contrasted the perceived usefulness of mathematics scale on one end with the mathematics as a male domain scale on the other. This function clearly discriminated among all five career interest groups. The group centroids were as follows; for fine arts (-0.51), for humanities (-0.31), for social sciences (-0.08), for biological sciences (0.17), and for physical sciences and mathematics (0.60).

The second function also yielded a significant chi-square ($\chi^2(24) = 39.92$, $p = .02$) with a canonical correlation coefficient of .13. The composite of attitude variables making up the second function contrasted the father scale on one end with the mathematics as a male domain scale on the other. An examination of the group centroids showed that this function basically discriminated between the social science and the biological science career interest groups (group centroids of 0.21 for the social science group and -0.14 for the biological science group). Although this function resulted in a significant chi-square, it is likely that this significance is primarily an artifact of the large sample size used in this study. Univariate ANOVAs generally failed to reveal differences between the attitudes of those interested in social sciences and those

interested in biological sciences. No other functions showed significant differences among the career interest group centroids.

Relationships between Attitudinal Variables and Gender

Table 10 includes the mean attitude score on each of the nine Fennema-Sherman Math Attitude scales for males and females. In order to explore the relationships between attitudes and gender, a series of analyses of variance (ANOVAs) was conducted. Results of these ANOVAs are presented in Table 11.

Males and females expressed different attitudes on five of the nine attitude scales; confidence in learning mathematics, attitudes toward success in mathematics, mathematics as a male domain, mathematics anxiety, and effectance motivation in mathematics. Males expressed more confidence in their abilities to learn mathematics, reported less mathematics anxiety, and found performing mathematical tasks more enjoyable. Females had more positive attitudes toward success in mathematics and were less likely to view mathematics as a subject area more appropriately studied by males than females or to express beliefs that males were intrinsically better at mathematical tasks than females.

Males and females felt mathematics would be equally useful to them in their future lives. Additionally, males and females reported no differences in their perceptions of

Table 10

Means for Attitudinal Variables as a function of Gender

	Males	Females
Confidence in Learning Mathematics	44.51	42.63
Mother Scale	45.99	45.65
Father Scale	44.29	44.42
Attitudes Toward Success in Mathematics	44.36	45.75
Teacher Scale	40.49	41.07
Mathematics as a Male Domain	47.28	52.63
Perceived Usefulness of Mathematics	46.61	45.96
Mathematics Anxiety	41.77	40.02
Effectance Motivation in Mathematics	38.84	37.64

Table 11

Results of Analyses of Variance (ANOVAs) for Attitudinal Variables as a Function of Gender

Variables	MS_e	F df = (1,1514)	p
Confidence in Learning Mathematics	112.07	11.92	.0006
Mother Scale	77.22	0.57	.45
Father Scale	68.05	0.10	.75
Attitudes Toward Success in Mathematics	53.36	13.62	.0002
Teacher Scale	67.76	1.88	.17
Mathematics as a Male Domain	87.35	123.84	.00001
Perceived Usefulness of Mathematics	100.83	1.59	.21
Mathematics Anxiety	109.98	10.56	.001
Effectance Motivation in Mathematics	92.61	5.88	.01

their mothers', fathers', or teachers' attitudes toward them as learners of mathematics.

Relationship between Gender and Mathematics Course-taking Plans

On a scale of 1 (definitely will not continue to take mathematics) to 5 (definitely will continue to take mathematics), the mean likelihood of continuing to take mathematics courses once participation becomes optional was 3.56 for males and 3.60 for females. An analysis of variance (ANOVA) showed that there was no difference between the course-taking plans of males and those of females, $F(1,1513) = 0.40$, $p = 0.53$, $MS_e = 1.66$.

Relationship between Gender and Career Interests

Career interests were subdivided into five categories, ranging from fine arts to physical sciences and mathematics. Frequencies of males and females who expressed interest in each of these categories are presented in Table 12. Chi-square analysis of the frequencies in Table 12 showed that the frequencies were not randomly distributed across the five interest categories (χ^2 (4) = 173.65, p =.000001).

A series of binomial tests was conducted to determine if males and females were equally likely to express interest in each interest category. The results were as follows: more females expressed interest in the fine arts category (Z = 6.52, p = .00001), in the humanities (Z = 2.45, p = .02,

Table 12

Frequencies with Which Males and Females Selected Each of the Five Career Interest Categories

	Males	Females	Row Total
Fine Arts	109	229	338
Humanities	44	70	114
Social Sciences	174	213	387
Biological Sciences	119	192	311
Physical Sciences and Mathematics	245	63	308
Column Total	691	767	1458

and in the biological sciences (Z = 4.09, p = .00001; there was no difference in the number of males and females who expressed interest in social sciences (Z = 1.94, p = .06); and more males expressed interest in the physical sciences and mathematics category (Z = 10.34, p = .00001).

Relationships between Attitudinal Variables and Mathematics "Track"

Table 13 includes the mean score on each of the nine Fennema-Sherman Math Attitude scales for four mathematics "track" levels; remedial (students enrolled in a mathematics course that is of a lower level than that of the mathematics course in which the average student of the same grade is enrolled), regular (students enrolled in a mathematics course of the level generally taken by a student in that grade), accelerated (students enrolled in a mathematics course that is of a higher level than that of the mathematics course in which the average student of the same grade is enrolled), and students enrolled in the middle school "special mathematics" course. In order to explore the relationships between attitudes and mathematics "track," a series of analyses of variance (ANOVAs) was conducted. The results of these analyses are presented in Table 14. Tukey HSD tests were conducted when post hoc analyses were warranted.

Table 13

Means of Attitudinal Variables as a Function of Mathematics "Track" Level

	Remedial	Regular	Accelerated	Special Math
Confidence in Learning Math	36.84	42.44	47.05	52.73
Mother Scale	39.67	45.06	48.41	52.80
Father Scale	39.11	43.63	46.79	50.80
Attitude Toward Success in Math	41.11	44.61	47.00	43.00
Teacher Scale	36.80	39.70	44.01	48.40
Math as a Male Domain	44.38	49.72	51.77	54.20
Perceived Usefulness of Math	39.74	45.87	48.08	53.27
Math Anxiety	34.75	40.38	42.72	48.47
Effectance Motivation in Math	33.56	37.66	40.07	46.13

Table 14

Results of Analyses of Variance (ANOVAs) for Attitudinal Variables as a Function of Mathematics "Track" Level

Variables	MS_e	F (df = 3,1515)	p
Confidence in Learning Mathematics	106.33	31.88	.00001
Mother Scale	73.14	28.79	.00001
Father Scale	64.63	26.81	.00001
Attitude Toward Success in Mathematics	52.24	17.32	.00001
Teacher Scale	63.09	38.08	.00001
Mathematics as a Male Domain	92.19	12.69	.00001
Perceived Usefulness of Mathematics	97.76	16.40	.00001
Mathematics Anxiety	108.08	14.66	.00001
Effectance Motivation in Mathematics	90.40	14.59	.00001

Attitudes toward mathematics varied according to mathematics "track" level on all nine attitude scales. The attitudes of students in the accelerated "track" and those in the "special mathematics" class were equivalent on all attitude scales and were significantly more positive than attitudes of students in regular or remedial "tracks" on all scales except attitudes toward success in mathematics and mathematics as a male domain.

Those in the accelerated "track" had more positive attitudes toward success in mathematics than students in either the regular or remedial "tracks" did. There was no difference between the attitudes toward success in mathematics held by members of the "special mathematics" class and those of students in any other mathematics "track" level. Students in the accelerated "track" were less likely than regular or remedial "track" students to view mathematics as an area of study that is more appropriate for males than for females. Those in "special mathematics" and those in the regular "track" held less stereotyped beliefs about the ability of females to perform mathematical tasks than remedial "track" students did. Additionally, students in the regular "track" expressed more positive attitudes than those in the remedial "track" on every attitude scale.

Relationship between Mathematics "Track" and Mathematics Course-taking Plans

The mean likelihood of continuing to enroll in mathematics courses once participation in mathematics becomes optional scores, on a scale of 1 (definitely will not continue to take mathematics) to 5 (definitely will continue to take mathematics) for the four levels of mathematics "track" were as follows: for the accelerated track ($\underline{M}$ = 4.32); for the regular track ($\underline{M}$ = 3.34); for the remedial track ($\underline{M}$ = 2.51); and for the "special mathematics" class ($\underline{M}$ = 4.40).

An analysis of variance (ANOVA) was conducted to determine if members of the four mathematics "track" groups were equally likely to express plans to continue to enroll in mathematics once such enrollment became optional. Likelihood of continuing in mathematics was found to vary as a function of mathematics "track" level, $\underline{F}$ (3,1514) = 82.36, $\underline{p}$ = .00001, $\underline{MS}_e$ = 1.44. Students in the accelerated track and students in "special mathematics" were equally likely to continue to take mathematics once it became optional and were more likely to express plans to continue to take mathematics than regular or remedial "track" students. Regular track students were more likely to continue in mathematics than remedial students.

Relationships between Mathematics "Track" and Career Interests

Frequencies of students in each of the mathematics "track" levels who expressed interest in each of the five career interest categories (ranging from fine arts to physical sciences and mathematics) are presented in Table 15. Chi-square analysis of the frequencies in Table 15 showed that the frequencies were not randomly distributed across the five interest categories (χ^2 (12) = 33.98, p = .00068). The career interests of students in the accelerated "track" and of those in the "special mathematics" group tended to be grouped toward the mathematics-oriented end of the interest continuum. Of the students in the accelerated "track", 76 percent expressed interest in careers in the social sciences, biological sciences, or the physical sciences and mathematics. Of those in the "special mathematics" group, 87 percent planned careers in the social sciences, biological sciences, or the physical sciences and mathematics. The interests of regular "track" students were fairly evenly distributed across the five interest categories. The interests of those in the remedial "track," however, tended to cluster toward the less mathematically oriented end of the scale with 80 percent expressing plans to pursue careers in fine arts, humanities, or social sciences.

Table 15

Frequencies with Which Students in Different Mathematics "Tracks" Expressed Interest in the Five Career Categories

	Remedial	Regular	Accelerated	Special Math	Row Total
Fine Arts	16	256	65	2	339
Humanities	4	78	32	0	114
Social Sciences	19	259	104	6	388
Biological Sciences	8	216	84	3	311
Physical Sciences & Mathematics	2	195	108	4	309
Column Total	49	1004	393	15	1461

Discussion

The findings of this study supported the hypotheses regarding the relationships of attitudes toward mathematics with mathematics achievement, mathematics course-taking plans, and career interests for secondary school-aged children and are consistent with results reported by other researchers (Eccles & Jacobs, 1986; Hackett & Betz, 1989; Kloosterman, 1988; Sherman, 1983). As predicted, all attitude variables were significantly positively correlated with mathematics performance (as measured by end of the quarter/semester mathematics course grade) and with the intention to continue to take mathematics courses once enrollment becomes optional. Students who expressed interest in careers that were more mathematically oriented had more positive attitudes toward mathematics. In addition, attitude variables significantly contributed to the prediction of final mathematics grade and mathematics course-taking plans and significantly discriminated among students with different career interests.

Support for hypotheses regarding the relationships between attitudes toward mathematics and gender was mixed. As predicted, males expressed more confidence in their ability to learn mathematics, had lower levels of mathematics anxiety, and described performing mathematical tasks as more pleasurable than females did. However,

contrary to expectations, females reported more positive attitudes toward success in mathematics and were less likely to view mathematics as a male domain. Additionally, males and females were equally likely to express plans to continue to participate in mathematics courses once enrollment becomes optional, perceived mathematics as equally useful to them in their future lives, and felt that the attitudes of their mothers, fathers, and teachers toward them as learners of mathematics were equally positive.

These results suggest that the gender differences in attitudes toward mathematics among secondary school-aged children observed by other researchers (Linn & Hyde, 1989) may be moderating. Many researchers (Eccles & Jacobs, 1986; Sherman, 1982) attribute the gender differences in mathematics acheivement commonly seen in the last years of high school and in college to differences in level of mathematical preparation in high school. It is, therefore, a positive finding that males and females in this study were equally likely to express plans to continue their mathematics education once course enrollment becomes optional. However, females still expressed less confidence in their abilities to learn mathematics. As found here and in other studies (Kloosterman, 1988; Schoenfeld, 1989; Sherman, 1983), confidence in learning mathematics is an

important variable in the prediction of both mathematics performance and course-taking plans.

Additionally, although females rejected the stereotyped statements that appear on the Mathematics as a Male Domain scale regarding the lack appropriateness of mathematics as an area of study for females, they expressed little interest in careers in mathematics and physical sciences. Over 80 percent of students who chose this career category were male. Therefore, although the failure of these results to fully support hypotheses regarding gender differences in mathematics attitudes and course-taking plans in favor of males is encouraging, the lack of confidence in learning mathematics and higher levels of mathematics anxiety expressed by females, in addition to their interests in less mathematically-related careers, suggest that important differences still exist.

The results supported the hypotheses that students in more advanced mathematics "tracks" would have more positive attitudes toward mathematics, would be more likely to express plans to take mathematics courses once enrollment becomes optional, and would be interested in more mathematically-related careers. The finding that accelerated "track" students expressed more positive attitudes toward mathematics than regular or remedial "track" students or that those in the regular "track" had

more positive attitudes than those in the remedial "track" is not surprising. The attitudes, plans, and interests of students in an experimental mathematics course (referred to as "special mathematics" throughout this paper) in relation to those of students in the standard "tracking" system are, however, interesting.

"Special mathematics" was developed at one middle school as an alternative to standard mathematics courses for students who tested in the top 2-3 percent of their 5th-grade class. Students generally enter the program at the beginning of 6th grade but may join up through the beginning of 7th grade and continue through the end of middle school. Students in 6th, 7th and 8th grade work together in the same class. Students are allowed to progress at their own pace and can work independently or with others, often engaging in cooperative learning. Students generally cover more material in three years than is covered in the standard mathematics "tracking" system, even by those students in an accelerated "track". Students in this program also had extremely positive attitudes toward mathematics.

On most of the Fennema-Sherman Math Attitude scales students in "special mathematics" had attitudes that were statistically equivalent to those of students in the accelerated "track" and were more positive than those expressed by students in regular or remedial "tracks."

However, upon examining the mean attitude scores presented in Table 13, students in the "special mathematics" class had higher mean attitude scores than students in the accelerated branch of the standard tracking system on all scales except Attitude Toward Success in Mathematics. Due to the small sample size of the "special mathematics" group these differences were not statistically significant. One could argue, however, that they are of practical significance. Some attitudinal differences between these two groups, such as in levels of confidence in learning mathematics, perceived usefulness of mathematics, mathematics anxiety, and amount of pleasure gained from working on mathematical tasks, were larger than those that were significantly different for groups with larger sample sizes. It is possible that it is something about the structure of this program, rather than just specific characteristics of the children involved in it, that breeds positive attitudes toward mathematics, intentions to continue studying it, and interest in mathematically-related careers. Given this possibility, expanding the use of some of the techniques utilized in this class (such as forming math "teams" and encouraging cooperative learning) to classes reaching a more general audience seems worthy of consideration.

An additional important point can be taken from the results of this study. Attitudes toward mathematics appear

to be solidly formed in secondary school-aged children. Even among children of this age, relationships between attitudes, mathematical performance, course-taking plans, and career interests are already in existence. Clearly these attitudes are being formed during the elementary school years (or perhaps even earlier). Educators have the opportunity to either alter or strengthen these attitudes that shape a child's educational path throughout a child's tenure in the school system. Negative attitudes can be changed (Hembree, 1990; Tobias & Weissbrod, 1980), but we must first identify the children in need of our help and then make it a priority to find ways to help them.

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Appendix A

Description of Fennema-Sherman Math Attitude Scales

Confidence in Learning Mathematics

This scale is a measure of how confident an individual is in his or her ability to learn mathematics. A high score is indicative of more confidence.

Mother Scale

This scale is a measure of an individual's perception of his or her mother's attitudes toward mathematics and toward the individual as a learner of mathematics. A high score is indicative of a more positive attitude.

Father Scale

This scale is a measure of an individual's perception of his or her father's attitudes toward mathematics and toward the individual as a learner of mathematics. A high score is indicative of a more positive attitude.

Attitude Toward Success in Mathematics

This scale is a measure of an individual's attitude toward success in mathematics. A high score is indicative of a more positive attitude.

Teacher Scale

This scale is a measure of an individual's perception of his or her teacher's attitude toward him or her as a learner of mathematics. A high score is indicative of a more positive attitude.

Mathematics as a Male Domain

This scale is a measure of the degree with which an individual believes that males are superior to females in mathematics or that mathematics is an area of study more appropriate for males than for females. A high score is indicative of less stereotyped beliefs.

Usefulness of Mathematics

This scale is a measure of how useful an individual perceives mathematics will be in his or her future life. A high score is indicative of more perceived usefulness.

Mathematics Anxiety

This scale is a measure of how anxious an individual feels about performing mathematical tasks. A high score on this scale is indicative of a low level of anxiety.

Effectance Motivation of Mathematics

This scale is a measure of how much pleasure an individual gets from working on mathematical tasks. A high score is indicative of more enjoyment.